Why Multi-Resolution Environments May Be the Wrong Solution:

Are We Really Asking the Right Question(s)?

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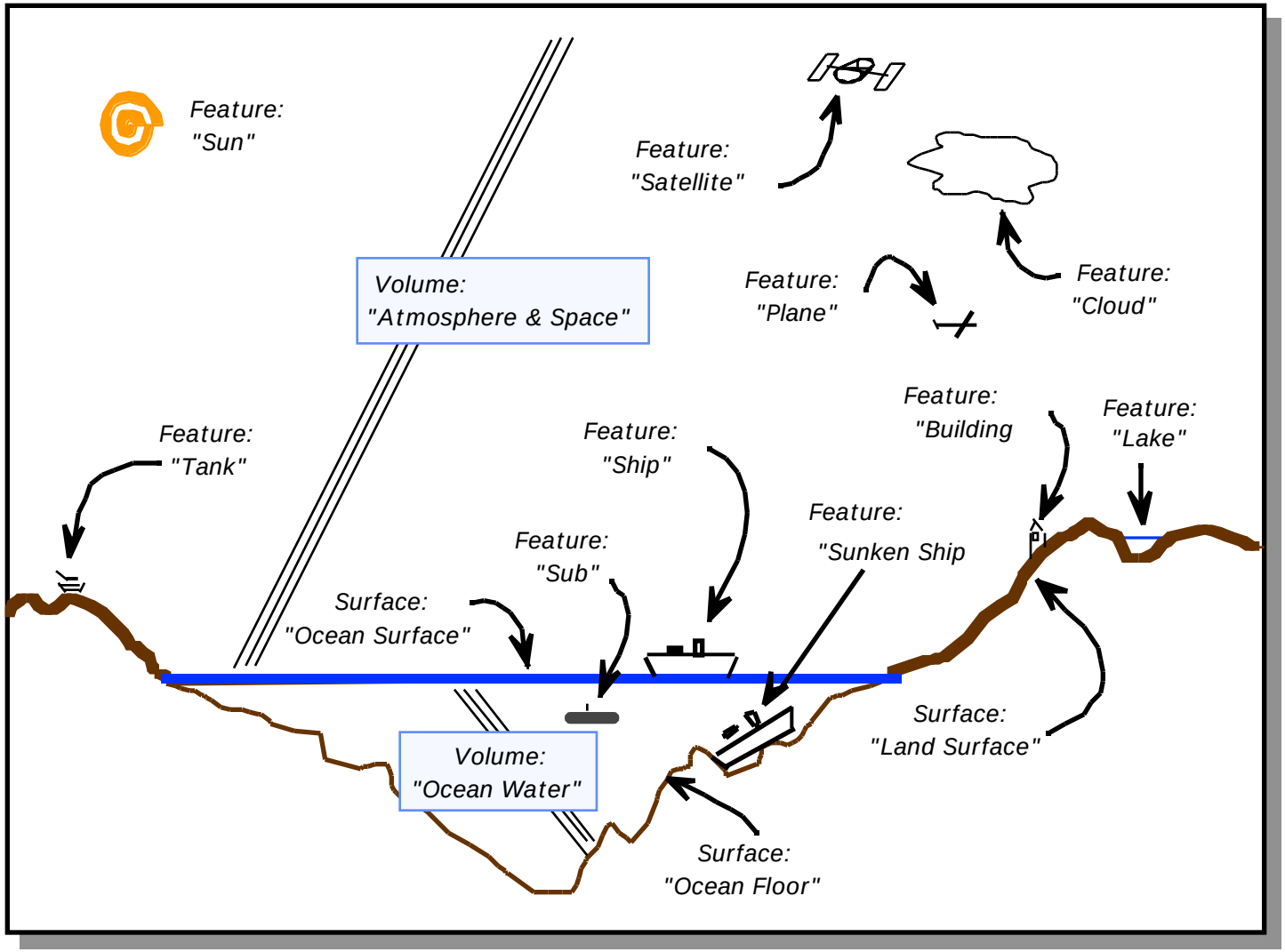
The Natural Environment

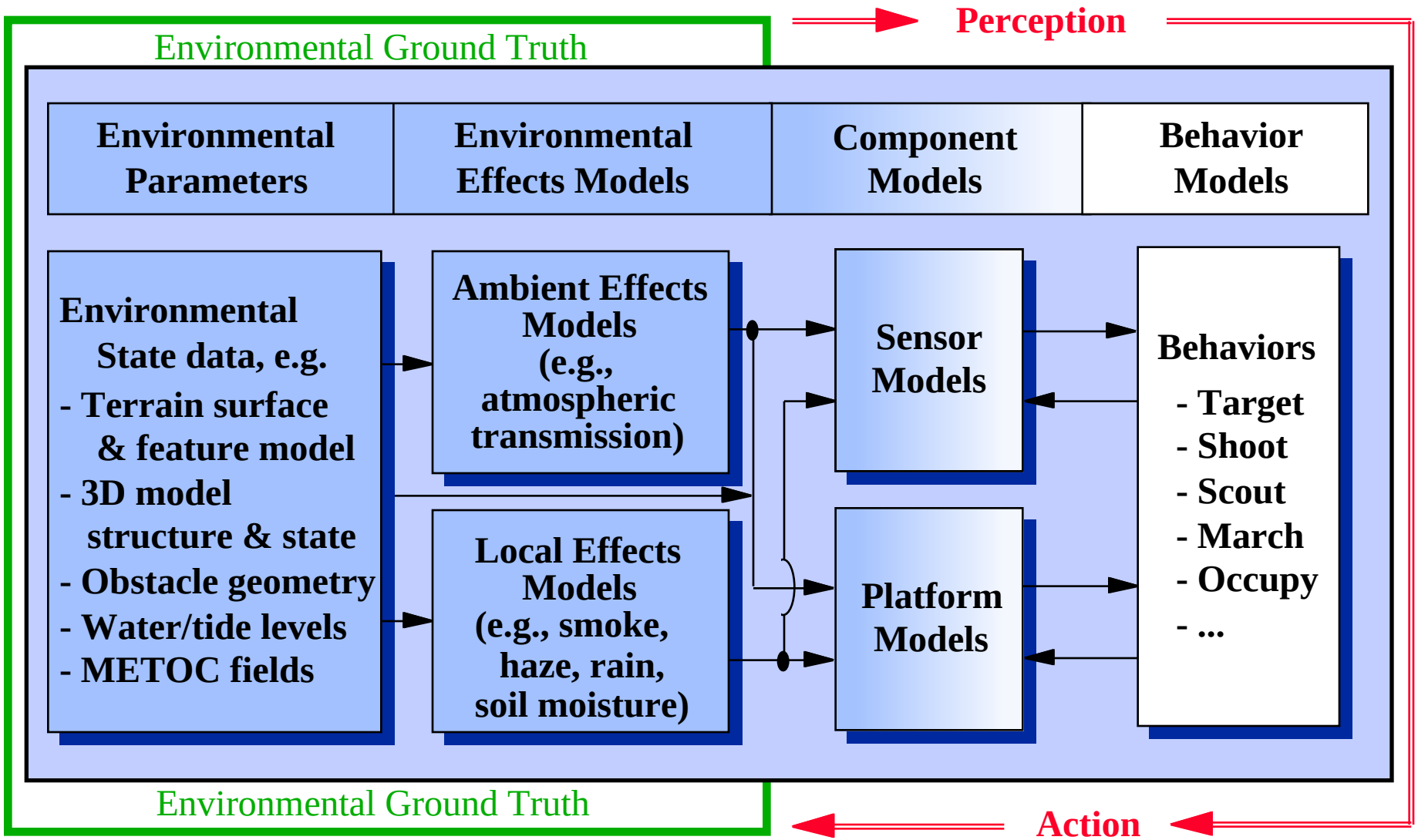


What is the Simulated Environment?

- **The representation of the Natural Environment which provides the "place" where the Simulated Forces operate**
  - Includes Littoral, Land, Sea, Air and Space

- **Modeling of the SE / SF can be roughly divided into:**
  - Environmental Parameters (environmental state data), e.g.
    - Terrain surface model
    - 3D Model structures & states
    - Water / tide levels
    - Terrain feature models
    - Obstacle geometries
    - METOC fields
  - Environmental Effects Models
    - Global (ambient)
    - Local
  - Component Models (sensors / platforms)
    - Environmental effects coupled to basic entity component infrastructure (e.g., tank vision block model, hull motion model, ...)
    - The mechanism by which the SF "perceives" the environment
  - Behavior Models
    - Target, shoot, scout, march, occupy, ...

Data Flows From SE to SF

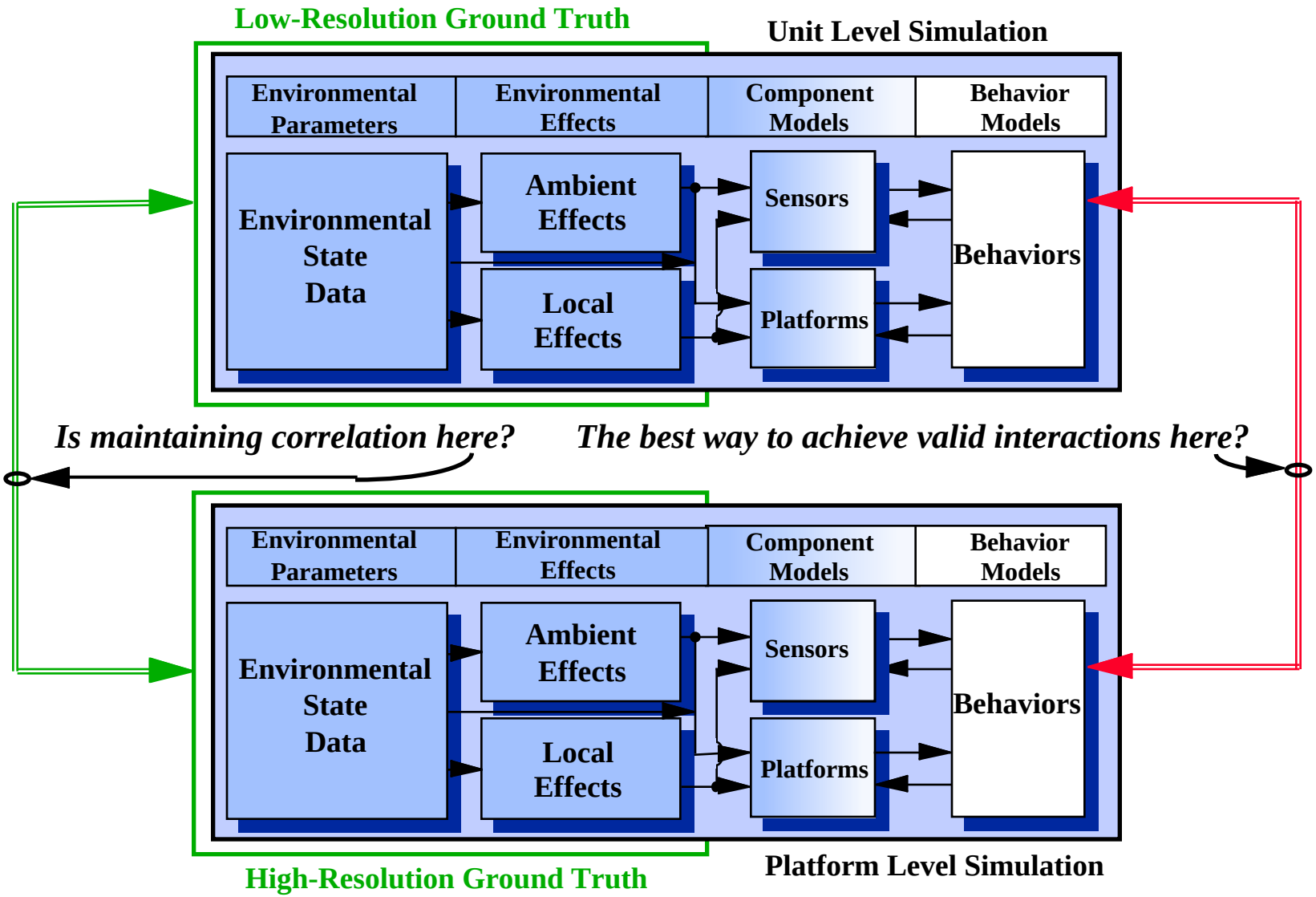


Assumptions

- **Focus: (without loss of generality)**
  - Ground or near-ground interactions
    - Army / Marine Corps focus
  - Ignore MITL (man-in-the-loop) simulation
  - Simplified mission space
    - Manuever to position assets
    - Projection of fire power
  - Simplified behavioral repetoire
    - Move, sense/target/shoot, ...
  - Ignore static vs. dynamic environmental data distinctions

- **Issue: *Require valid interactions among Simulated Forces with varied resolutions*, e.g.**
  - Platform level (tanks, planes, ships)
  - Unit level (platoon, company, battalion, ..., corps, army)

The Critical Question



The Critical Question Restated

- **Is maintaining correlation between multi-resolution environmental ground truth databases ---**

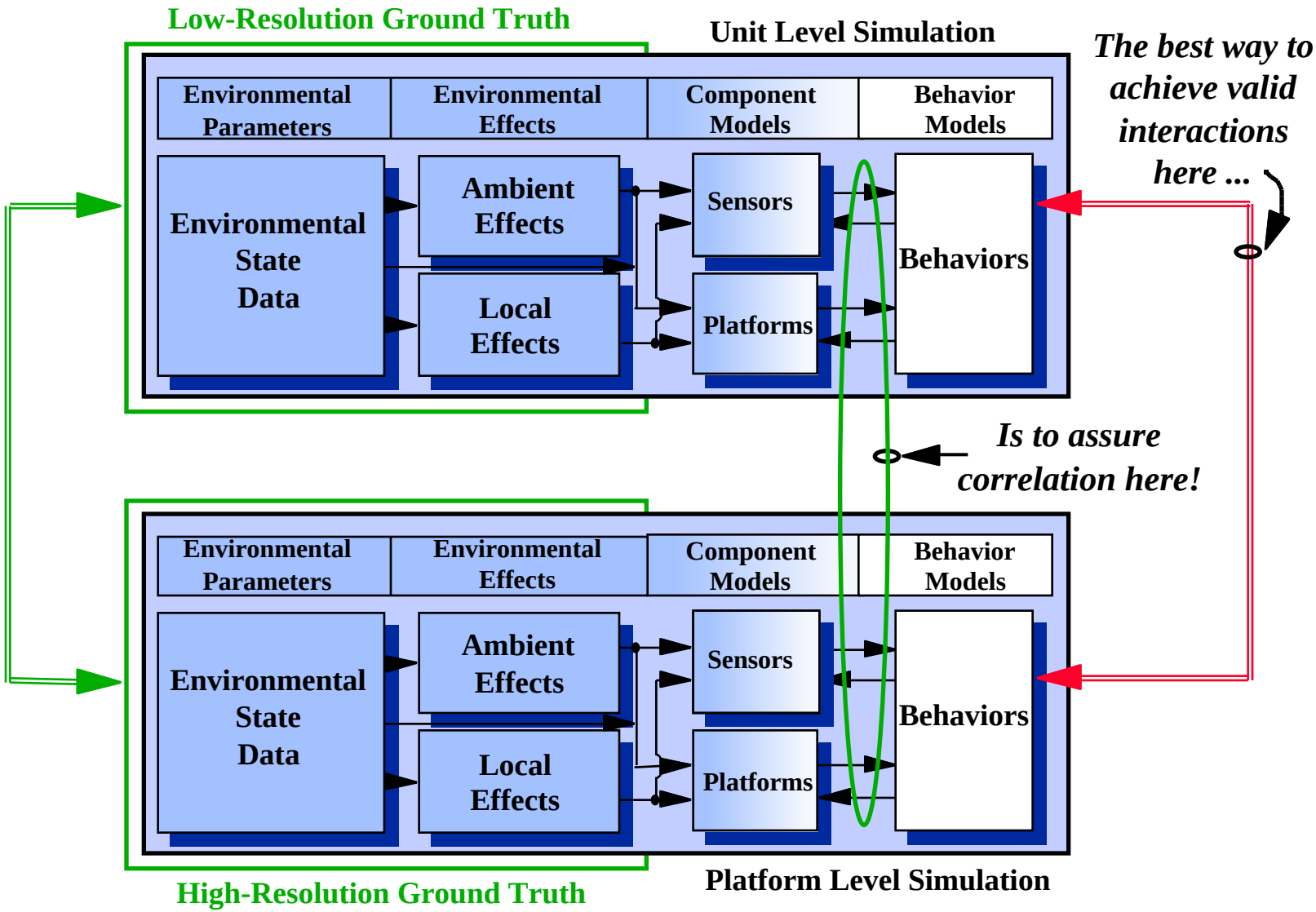
  the best way to achieve valid interactions among multi-resolution Simulated Forces?

  - *Maybe, but not necessarily!*

- **Assuring consistent perceptions of environmental state <u>also requires correlated Simulated Force component models</u>**

  - *Interoperability can be destroyed by inconsistent component models despite identical environmental state models!*

The Hypothesis



The Hypothesis Restated

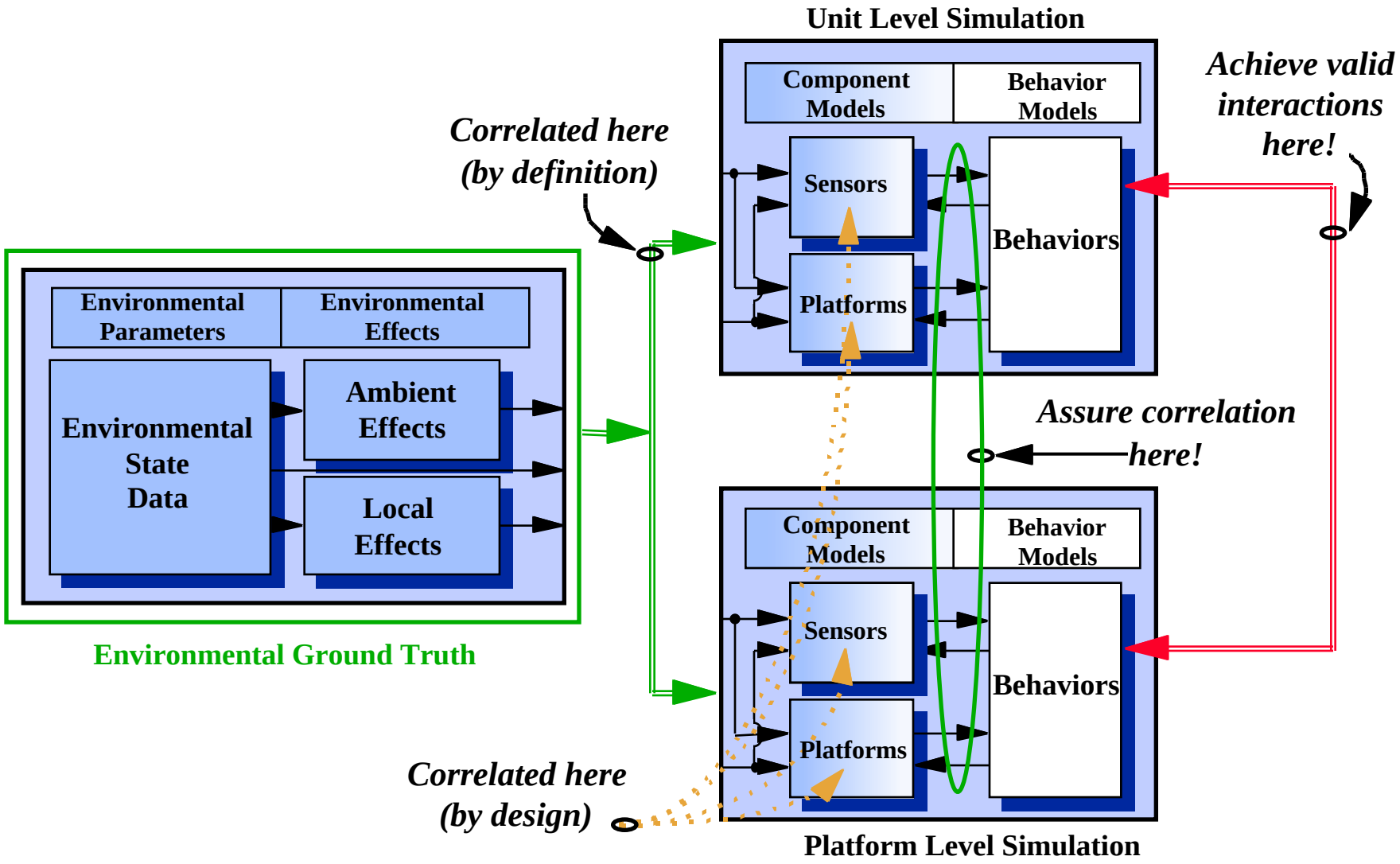
- **The best way to achieve valid interactions among multi-resolution Simulated Forces (wrt SE) ---**

  is to assure perceptual correlation as mediated by Simulated Force component models

- **This requires that:**
  - Component model inputs be correlated
    - E.g. correlated multi-resolution environmental ground truth databases
  - Component models themselves be correlated
    - E.g. *correlated multi-resolution component models*

- **Note that this formulation of the problem allows for the possibility of <u>completely dropping the requirement for multi-resolution environmental databases</u> as they are functionally isolated from behaviors by component models**

A Proposal


Unit Level Simulation
Component Models
Behavior Models
Sensors
Platforms
Behaviors
Achieve valid interactions here!
Correlated here (by definition)
Environmental Parameters
Environmental Effects
Environmental State Data
Ambient Effects
Local Effects
Environmental Ground Truth
Assure correlation here!
Component Models
Behavior Models
Sensors
Platforms
Behaviors
Correlated here (by design)
Platform Level Simulation

The Right Questions

1. **What constitutes "equivalent perceptions of the environment" in multi-resolution simulation?**

2. **What perceptual outputs are required from component models at different Simulated Force resolution levels?**

3. **What are the performance requirements for the multi-resolution component models?**

4. **What environmental inputs do these multi-resolution component models require (and how often)?**

5. **When is pre-computing a low-resolution environment and maintaining its correlation with a dynamic high-resolution environment better than simply maintaining a single (high-resolution) environmental model?**

Question #1

What constitutes "equivalent perceptions of the environment" in multi-resolution simulation?

- **A really tough question!**
  - But gets at the heart of establishing interoperability in a multi-resolution force simulation ...
- **Strawman:**

  Cues that result in "equivalent / consistent behavior" in "same situation"
  - S2/G2/J2 example: (sensing / intelligence)
    - Detection, classification, recognition, identification
  - S3/G3/J3 example: (movement / manuever)
    - Go, Slow-go, No-go
    - Routes, corridors, avenues
- **Driven by simulation objective(s); e.g. JTF training**

Question #2

What perceptual outputs are required from component models at different Simulated Force resolution levels?

- **Platform level**
  - Support platform-to-platform interactions, e.g.
    - Sensor and weapon system emulation (e.g. LOS)
    - "Hull" motion emulation (e.g. placement and local conditions)
  - (Perhaps) automatic selection of appropriate sensor parameters to optimize target detection given environmental conditions
- **Unit level**
  - Support "roll-up" (or emulation) of subordinate force inputs, e.g.
    - Composite sensor coverage (areal union, enhancements due to overlap)
    - Speed-made-good while maintaining formation
- **Specific outputs and correlation across multi-resolution environments are not well understood**

Question #3

What are the performance requirements for the multi-resolution component models?

- **Unknown, but reasonable starting assumption:**

  Constant proportion of total computational effort may be spent in assessing environmental situation at any specific simulation resolution

- **Probably desirable to spend proportionally <u>less</u> effort in low-resolution environments**

- ***Certainly desirable to not spend more effort!***

- **Traditional approach is to allocate "remaining effort"**
  - Usually ends up with very anemic component models (& environment)

Question #4

What environmental inputs do these multi-resolution component models require (and how often)?

- **Platform level**
  - Sensors: line of sight conditions (surface & obscurants)
    - Basically, once each behavior simulation unit time
  - Platforms: local surface conditions
    - Typically every simulation "tick" (critical for physics; e.g. 1+/sec.)
- **Unit level**
  - Statistical (and aggregated) models often used
    - Spatially: locations as center-of-mass, vegetation/obstacles as "typical"
    - Temporally: average unit-composition vehicle performance
  - Performance no better than once per behavior simulation unit time
    - May be less based on crude "dead-reckoning"
- **Specific inputs and correlation across multi-resolution environments are not well understood**

Question #5

When is pre-computing a low-resolution environment and maintaining its correlation with a dynamic high-resolution environment better than simply maintaining a single (high-resolution) environmental model?

- **Depends on trade-off against running low-resolution component models on high-resolution environment**
  - Caching of environmental abstractions may be key, e.g.
    - Military crests, relatively high terrain, key terrain
    - Mobility corridors, avenues, other OCOKA/IPB results
- **Difficult to accomplish when environmental dynamics must be taken into account**
- **Trade-off space has never been explored**
  - Traditional solutions for pure low-resolution environment not necessarily interoperable (ever) with high-resolution environment